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Crew coordination error has been identified by the Naval Safety Center as the number one cause of Naval Aviation mishaps. To address the problem of crew coordination all Fleet Replacement Squadrons were directed to implement a training program for all Naval Aircraft. Patrol Squadron Thirty-One was tasked to implement crew coordination training for P-3 fleet replacement students and for fleet squadrons. A one day seminar was developed and implemented for Moffett Field and Barbers Point P-3 squadrons. To measure the effect of crew coordination training the Cockpit Management Attitudes Questionnaire was administered to crewmembers prior to and after the seminar. Based on the results of the questionnaire, attitudes that lead to effective crew coordination are enhanced by the seminar. Utilizing t-tests of before and after questionnaire responses, significant changes in attitudes for crewmembers were identified and explained.

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Analysis of P-3
Aircrew Coordination Training

by

John G. Kinney
B.S., Sacramento State University, 1983

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANPOWER, PERSONNEL
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from the

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ABSTRACT

Crew coordination error has been identified by the Naval Safety Center as the number one cause of Naval Aviation mishaps. To address the problem of crew coordination all Fleet Replacement Squadrons were directed to implement a training program for all Naval Aircraft. Patrol Squadron Thirty-One was tasked to implement crew coordination training for P-3 fleet replacement students and for fleet squadrons. A one day seminar was developed and implemented for Moffett Field and Barbers Point P-3 squadrons. To measure the effect of crew coordination training the Cockpit Management Attitudes Questionnaire was administered to crewmembers prior to and after the seminar. Based on the results of the questionnaire, attitudes that lead to effective crew coordination are enhanced by the seminar. Utilizing t-tests of before and after questionnaire responses, significant changes in attitudes for crewmembers were identified and explained.

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I. AIRCREW COORDINATION TRAINING

A. STATEMENT OF THE OBJECTIVE

The purpose of this report is to measure attitudinal change resulting from aircrew coordination training. Attitudinal change is necessary for the ultimate goal of this training program to be achieved. A training program with concepts and theories adequate to cause attitude change, should result in behavior change because attitudes and behavior are assumed to be linked (Helmreich, Foushee, Benson, Russini, 1986). Behavior more conducive to safe operation of aircraft is the ultimate goal of Aircrew Coordination Training.

This thesis examines the attitude changes occurring in P-3 Orion aircrew personnel who have attended training administered by Patrol Squadron Thirty-One. The Cockpit Management Attitudes Questionnaire (Helmreich, Wilhelm, and Gregorich, 1988) was administered to seminar participants prior to and immediately after completion of training. Changes in the responses of survey participants may be indicative of changes in attitudes caused by training (Helmreich, Foushee, Benson, Russini, 1986). The consistency and magnitude of changes may provide patterns of change indicative of aircrew coordination training effectiveness or ineffectiveness. This report will attempt to identify and explain the significance of survey response changes.

B. BACKGROUND

1. Aircrew Coordination Training Origins

There has always been an inherent element of risk associated with the flight of aircraft. As advancements in flight operations have occurred, the element of risk has been sufficiently reduced to make aircraft operations practical for a multitude of purposes. Significant improvements in aircraft design, air traffic control and weather forecasting have reduced the danger of flight operations.

Significant events in the development of crew coordination training are detailed by Manningham (1986) starting with events during the early 1970s. The term "pilot error" was an often used description applied to explain many mishaps. Researchers at the National Aeronautics and Space Administration conducted interviews and observed the performance of crews to further understand the cause of "pilot error." Investigations into the 1972 crash of an airliner into the Florida everglades, a 1985 crash of a Lockheed Electra soon after takeoff in Nevada and other mishaps identified the failures resulting from poor crew coordination. The severity and complexity of crew coordination error was recognized by the National Transportation and Safety board and the Federal Aviation Administration. The need for a new approach to crew training was identified. To meet this need individuals from all sectors of aviation have sought to understand crew coordination error. The results of approximately fifteen years of research have been the development of crew coordination training programs that are now a part of almost every aviation training program.

Human factors research has determined that pilot experience, age and time of day are three important variables in aviation safety. Research has identified the "Most Dangerous Pilot" (Borowsky 1990) as one who has only five hundred hours or less experience in the assigned aircraft and less than one thousand hours total. A newly qualified P-3 aircraft commander in many cases fits this description, and is supported by second and third pilots who have even less experience. As pilots age they become less likely to make the skill errors common to junior pilots but become more likely to make procedural errors. Familiarity tends to cause complacency in more senior Navy pilots. Further, a dramatic increase in the number of mishaps per 100,000 flight hours occurs as pilots fly during the 1800-2400 hour time frame. During night time hours, the mishap rate increases from 2 to 4.2 mishaps per 100,000 flight hours(Borowsky, 1990). Inexperience, age and time of day are important and known tendencies.

There is yet another human factor that is more significant than inexperience, age or time of day. At present, the most significant causal factor in aviation mishaps is crew coordination error. Aircrew error accounted for 55 percent of the overall Navy/Marine mishap rate during the years 1985 through 1990 (Borowsky,1990). The cost of aircrew error during this time was 245 invaluable lives and 187 aircraft worth 1.7 billion dollars (Borowsky, 1990)[1] .

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[1]Written permission from the Commander Naval Safety Center was obtained to allow utilization of Naval Aviation mishap data.

The need for extensively trained personnel to operate aircraft is recognized by civilian and military aviation authorities. Training programs to date have emphasized thorough knowledge of aircraft systems, and flight procedures. However, reconstruction of past aviation mishaps has identified human failures not addressed by traditional training programs. Fully qualified and extensively trained personnel have become involved in mishaps due to human error. The nature of this other category of human error has been identified and is the target of new training programs in civilian and military aviation. The field of study supporting the research and training is widely known as Cockpit Resources Management. Recognizing the important role of crewmembers other than cockpit personnel, the Navy has entitled its program Aircrew Coordination Training (ACT).

2. Aircrew Coordination Training Development

Interest in ACT research and training has developed because human error is the most significant cause of aviation mishaps. The type of errors that are the focus of ACT include errors of decision-making, judgment, and communications [Cooper, White, Lauber, 1980]. Analysis of cockpit simulator training demonstrates that crews who more effectively utilize crew coordination concepts, are more successful when coping with in-flight emergencies [Foushee and Manos, 1981]. Dr. John K. Lauber of the National transportation Safety Board defines ACT as:

> The effective utilization of all available resources—hardware, software, and liveware—to achieve safe, efficient flight operations (Lauber, 1986).

Organizations currently devoting resources to ACT research and implementation include the Federal Aviation Administration, National

Aviation and Space Administration, National Transportation Safety Board, commercial airlines, military aviation and universities. Improvements in crew coordination are the focus of so many groups because of the necessity for improvement.

ACT Training programs vary widely in content and method of implementation. Significant research into ACT has produced a theoretical base too large for a single program to cover. ACT training programs must choose the most appropriate material considering resources available to implement a program and the mission of the aircraft. A resource intensive method of implementation includes the use of flight simulators. Via observation of simulator events the practicality and need for ACT was first demonstrated. Simulator training is highly useful for decision-making, communication and coordination training [Foushee and Manos 1981]. The alternative to simulator training is classroom instruction. The P-3 ACT course utilizes classroom instruction combined with role play exercises to demonstrate ACT concepts. Future P-3 ACT courses may incorporate the utilization of simulators if the resource is made available.

3. The Aircraft

The Lockheed P-3 Orion aircraft has been utilized by aircrews of the United States Navy since 1962 for maritime patrol operations (Figure 1.1). The primary mission of the aircraft is anti-submarine warfare. Squadrons of P-3 aircraft are deployed throughout the world on a continuous basis, monitoring maritime activities of other nations. The aircraft is capable of transoceanic flights in excess of fifteen hours (P-3C Flight Manual, 1983). The current version of the aircraft is operated by a crew of twelve including: three

pilots, two flight engineers, two acoustic equipment operators, a tactical coordinator, navigator, radar operator, in-flight technician and ordnanceman. The twelve members form a combat air crew. To allow improved teamwork and efficiency, combat aircrews conduct all training and operational missions as an intact twelve-member group. The crew is responsible for operation of an extensive variety of electronics equipment designed to allow detection, tracking and attack of submarines and ships. The aircraft is capable of carrying mines, torpedoes, anti-ship missiles and gravity bombs to carry out wartime missions.

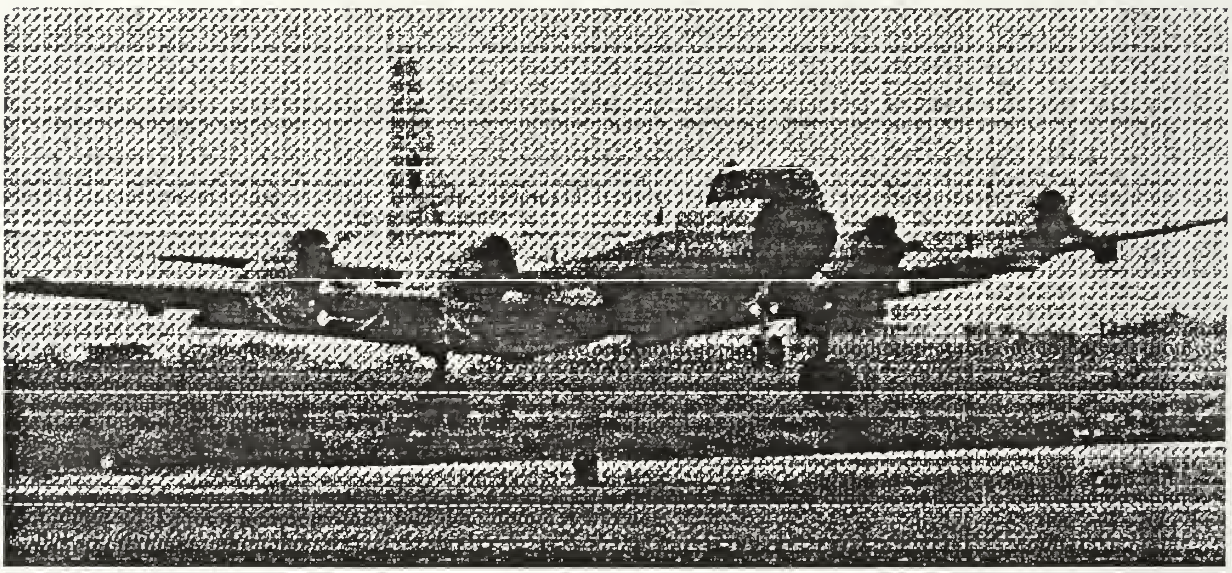

Figure 1.1. United States Navy P-3C Orion

4. P-3 Orion Mishap History

The P-3 Orion began operation in the U.S. Navy fleet in 1962. Since that time forward deployed squadrons have been patrolling the waters of the Atlantic, Indian, Pacific and Mediterranean oceans. During the twenty-nine

years of operation thirty-four aircraft have been destroyed and 247 lives have been lost as a result of mishaps [(Hess, 1983), (Borowsky, 1992)][2]. Despite the large loss of life the P-3 is considered safe relative to other aircraft in naval aviation. For the years 1985-1991 the F/A-18 mishap rate per 100,000 flight hours was 4.23, whereas the P-3 mishap rate was .19 (Borowsky, 1991). Of the thirty-four P-3 aircraft destroyed, twenty were destroyed while at forward deployed locations. Figure 1.2 shows that eight of the thirty four mishaps were known to be caused by mechanical error, twenty-four were in part caused by aircrew error and two were due to unknown causes (Hess, 1983, Borowsky 1992).

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[2]Aircraft destroyed were involved in Class A mishaps. OPNAV instruction 3750.6Q defines a Class A mishap an event where total damage is $1,000,000 or greater; or the aircraft is destroyed or missing; or a fatality or permanent total disability occurs with direct involvement of Naval aircraft.

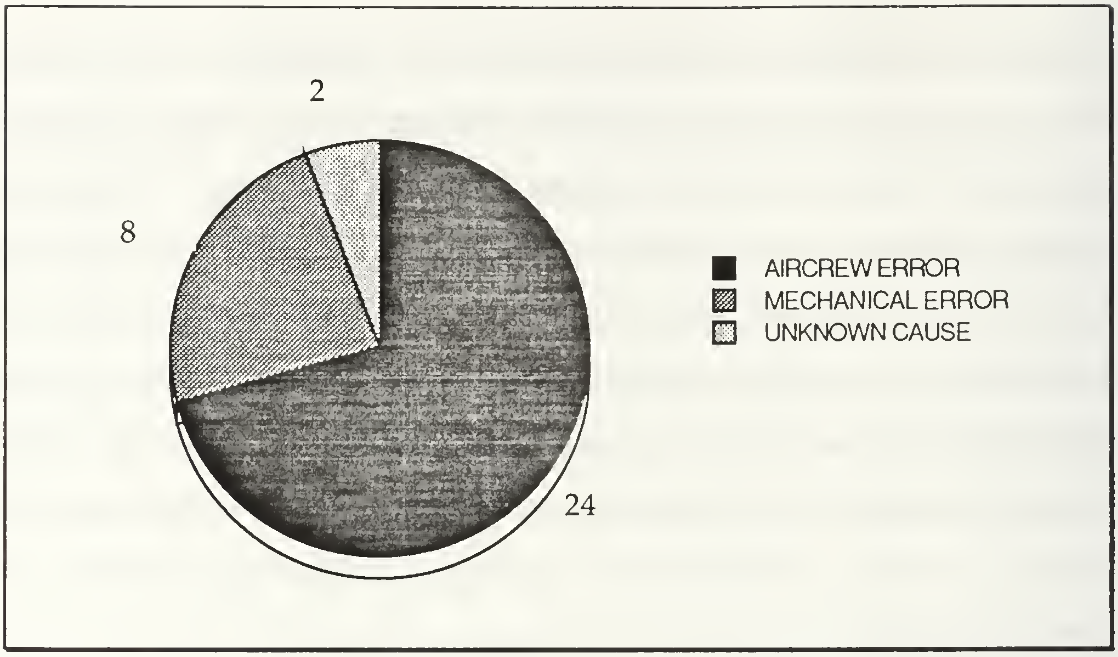

Figure 1.2. Causes of P-3 Class A Mishaps 1963-1992

II. P-3 AIRCREW COORDINATION TRAINING

A. TRAINING PROGRAM IMPLEMENTATION

As authorized by Commander Patrol Wings Pacific, Patrol Squadron Thirty-One was tasked to provide Aircrew Coordination Training for all P-3 squadrons based at Naval Air Station Moffett Field and Naval Air Station Barbers Point. Patrol Squadron Thirty-One is the west coast P-3 fleet replacement training squadron. Under the direction of the command training specialist, Dr. Henry H. Smith, the squadron first trained its own group of facilitators. Utilizing the command training specialist plus a cadre of its own instructor pilots and flight officers, Patrol Squadron Thirty-One completed seminars at each squadron. The initial seminars were followed by the training of facilitators from each squadron who then completed the task of training all twelve combat aircrews.

B. SEMINAR DESIGN

The P-3 Orion Aircrew Coordination Training seminar is designed to be facilitated by two squadron instructors who guide a combat aircrew through an eight-hour progression of concepts and ideas relevant to flight safety and efficient crew coordination (VP-31 ACT Facilitator Guide, 1989). Key to the success of the program is the concept of allowing each squadron the opportunity to select its own instructors. Internally selected instructors are more easily accepted and are more capable of understanding the perspectives of trainees. Aircrew Coordination Training Instructors utilize a facilitator

guide, instructional guide and flip-chart and video presentations during the day-long course. Ideally, the setting for the seminar is a relaxed atmosphere wherein participants wear flight suits instead of uniforms, form a circular seating arrangement for ease of conversation and are encouraged to offer their views on the concepts at any point during the seminar. A full eight hours of discussion is usually required to complete the seminar, including a working lunch wherein members are encouraged to order out pizza or sandwiches for the group. The setting for the seminar, ideally, is away from the squadron so that interruptions are kept to a minimum allowing crewmembers to focus on the material presented. Critical to the success of the program is the promise of confidentiality to crewmembers who share personal information with the group. Incidents that have nearly resulted in aviation mishaps eventually happen to all crewmembers and provide valuable material for the seminar. The entire discussion is confidential among the crew and the facilitators. Only the promise of confidentiality will allow open and frank discussion of ideas and experiences.

C. COURSE ORIGINS AND CONTENT

The field of Cockpit Resources Management, includes a broad base of knowledge put together over several decades of research and application. A variety of Cockpit Resources Management programs are being presented world wide to aircrews of civil and military aircraft. Each program is different, as the needs of the organization or the mission of the aircraft dictate the content of the course.

The P-3 ACT course is a version of the program put together by three Air Force Reserve pilots. Lt.Col. Biegalski, Lt.Col. Halliday Major Houle and Major Inzana designed and implemented an ACT course for crews flying the C-5 transport aircraft (Halliday, Biegalski, Inzana, 1986). The course structure is guided by the concept that the goal of ACT is to provide the aircrew with something immediately useful and practical. Videos and taped role plays are used to demonstrate ACT concepts and to provide feedback. Like the P-3 version of their course, the C-5 course facilitators guide a day-long discussion in a classroom environment. The link between Air Force ACT and P-3 ACT, is Dr. Henry H. Smith who modified, tested and implemented a revised version of the Air Force course. With the support of Patrol Squadron Thirty-One Commanders Alford, Bozin and Hull, and Dr. Smith integrated ACT into the VP-31 fleet squadron training program.

The content of the course offered to the aircrews of the United States Navy P-3 Orions is structured to suit the unique features and mission of the airplane they fly. There are five main sections to the P-3 aircrew coordination training course (VP-31 ACT Instructor Guide, 1990). The five main sections include:

- Synergy
- Team Creation/Building
- Style of Personality
- Communication
- Decision Review

D. OBJECTIVES AND METHODS OF P-3 ACT

Each section included in the P-3 aircrew coordination training course is designed to achieve specific objectives critical to aircraft safety. The objectives expand and emphasize concepts participants are familiar with in practice but lacking in understanding and application. The course material emphasizes application of the objectives through education, demonstration and role play activities.

1. Synergy

Synergy occurs when the whole of an aircrews' effort is greater than the sum of its parts. Synergy occurs when crewmembers work together as a team. The P-3 Aircrew Coordination Instructor Guide indicates that synergy will only occur when all share a joint and co-equal sense of responsibility for the safe completion of a flight. Lack of synergy has been responsible for many previous aviation mishaps wherein a crewmember fails to volunteer or accept information necessary to prevent a mishap.

Synergy is difficult to achieve because of conditioning that leads to withholding information critical of other crewmembers. Information is withheld because of barriers between crewmembers. For example, in the military relative rank can create a barrier. Junior ranking personnel are reluctant to correct the mistakes of senior ranking personnel. Lack of experience can be intimidating for a recently trained crewmember. Inexperienced personnel have failed to offer valid information because they lacked confidence in their abilities or were intimidated by a senior person (VP-31 ACT Instructor Guide, 1990).

For synergy to be achieved all crewmembers must recognize the responsibility of offering their observations to others. All crewmembers must be receptive to information offered to them. This requires that barriers to the transfer of information be sufficiently reduced for information to be exchanged, no matter what the rank or experience level involved.

Synergy is demonstrated to seminar participants through a general knowledge quiz. Subsequent to the quiz individual scores are tallied. Individuals normally score in the range of seven to ten correct scores out of twenty. The group is then allowed to work together on the quiz. Group scores tend to significantly exceed the score of any individual. Groups regularly come up with eighteen to twenty correct answers on the quiz, demonstrating the effect of synergy.

2. Team Creation/Building

Richard Hackman of Harvard University, developed an aircrew behavior model titled the Life Cycle of the Crew. The model explains elements of crew behavior critical to safe flight operations (Hackman, 1989). During the course of a flight the crew will progress through several phases of team development. Crews proceed through the phases of team development with differing degrees of effectiveness. Dr. Hackman identified the following four distinct phases of the Life Cycle of the Crew:

- Team Creation
- Team Building
- Team Acting/Execution
- Team Termination

The team creation phase occurs when members of a flight crew first meet to discuss a flight. The team creation phase only lasts for five to ten

minutes. During this time the flight crew leadership, a Pilot or Flight Officer, establishes the behavioral norms as related to safety, communication and cooperation. Hackman observed that the norms established at the initial briefing usually become fixed for the remainder of the flight.

To effectively emphasize the importance of safety, the initial team creation phase must establish the expected level of regard for safety. Crewmembers should be encouraged to avoid unsafe practices and look for hazardous situations that could affect others. For effective communication to occur on board the aircraft, barriers to communication must be overcome. Barriers to communication include: superior/subordinate relationships, fatigue, distractions, noise, workload, instructor/student relationships and communication by interphone. Crewmembers should be encouraged to overcome the barriers to communication when important messages must be conveyed. The importance of cooperation in the role of mission success should be established from the outset of the briefing. Cooperation requires that crewmembers assist others when their work is completed. Safety, communication and cooperation are key elements in the Life Cycle of the Crew.

To illustrate concepts defined by Hackman, a video presentation of a briefing emphasizing the utilization of these concepts is shown to seminar participants. The video includes a twelve-member P-3 crew conducting an initial briefing for a surface ship surveillance flight. Following the video tape, participants are given a hypothetical mission assignment and asked to conduct their own briefing. After completion of their mission brief, crewmembers view a video playback to observe their ability to include safety,

communication and cooperation as part of a briefing. The next three phases in the Life Cycle of the Crew are addressed by a discussion with seminar participants led by the facilitators.

Team building occurs during spare moments before and during flight. Aircrew who choose to interact during this time are better able to communicate during the mission phase. Team building communication addresses events that will affect the crew including: the addition of a new member, destination billeting, inflight meals and other factors affecting a crewmember's performance. The team Acting/Execution phase occurs during flight when crewmembers perform their duties. This is when the ability of the crew to handle safety and mission related activities is carried out. The team termination phase occurs after mission completion when crewmembers recapitulate events. During team termination, crew coordination successes or failures should be identified and lessons learned from them.

3. Style of Personality

Personalities of individuals on a crew can affect quality of interaction among crewmembers. For synergy to exist, crewmembers should have knowledge of differing styles of personalities. Four distinct styles of personalities are compiled into a behavior model for the seminar. Distinctive styles are given names to allow easy association and understanding. The styles of personality discussed are the driver, analytical, amiable and expressive. The driver is said to be: industrious, systematic, persistent, detail oriented, serious, exacting and precise. The analytical person is characterized as: objective, determined, requiring, independent, pragmatic, efficient and

decisive. Amiable personalities are: supportive, loyal, friendly, responsive, dependent, easy going and cooperative. The expressive personality is: imaginative, out-going, stimulating, enthusiastic, spontaneous, fun-loving and ambitious.

Facilitators lead the discussion and explain to crewmembers how personality can affect achievement of synergy. No attempt to modify personalities is done by the course. Personalities are assumed to be fixed (Gregorich, Helmreich, Wilhelm, Chidester, 1989). Crewmembers must learn to adapt to each other to promote synergy. Each personality style can affect the crew in positive and negative ways. Effective synergy is achieved when a crew can combine the best attributes of each personality. The discussion of personalities is intended to promote the awareness of personality as a major factor in crew interaction and illustrate how crewmembers can adapt to each other. Through education a crew should be more able to cope with the four personality groups identified in the seminar.

4. Communication

The third model introduced is the cornerstone of the seminar. The model is named the Synergy Formula and it is composed of three parts:

- Questioning
- Promoting
- Conflict

These concepts are the critical elements in the communication process that affect a crew's ability to cope with challenging flight scenarios. When circumstances occur that could result in development of an unsafe situation, crewmembers should question what is occurring, promote their

concerns about action taken and seek to resolve conflict. Facilitators explain the concepts and give practical examples of their utilization.

Questioning, in the context of aircrew coordination training, is an attitude that all crewmembers should possess. Each crewmember should always be aware of the current phase of flight and plan of action. By constantly checking one's actions and cross checking actions of others, mistakes can be detected early and corrective action taken. Facilitators encourage junior personnel to cross check actions of more experienced crewmembers. Senior crewmembers are encouraged not to feel threatened by a junior crewmember questioning their actions. Questioning requires that crewmembers learn to doubt the status quo is correct and accept that everyone is capable of making mistakes.

Promoting is recognition and encouragement for crewmembers to be assertive when necessary. A group interaction decision-making phenomena, group think, can cause inferior decisions to be made by the group (Janis, 1972). To avoid group think behavior, an individual who believes his/her opinion is correct and that the group is wrong should voice that opinion until a satisfactory answer is provided. Facilitators explain promoting as a responsibility inherent in assignment to an aircrew. Crewmembers are not qualified until they have demonstrated a satisfactory level of competence. A qualified crewmember is responsible for being assertive and expressing concerns not addressed by the present course of action. Qualified crewmembers should not tolerate a situation if they are not satisfied with the course of action and have not received a satisfactory answer to their concerns.

Conflict is a desirable element and necessary for optimum crew coordination. Crewmembers must learn to resist tendencies to avoid conflict out of respect for rank or experience. Conflict is a natural result of questioning and promoting. Conflict occurs as crewmembers approach situations with different values, experience, training, opinions and personalities. A crew able to effectively utilize conflict can realize benefits. Ideally, conflict will lead to better problem solving, deeper thinking and a more effective decision making process.

5. Decision Review

Decision Review is the method used to put synergy into effect. Decision Review is also known as a Bubba Review. By utilizing a word not popular in present vernacular, the Bubba review is immediately associated with the synergy model. A crewmember who identifies an unsafe situation developing should demand a Bubba Review. During a Bubba Review, questions causing concern are promoted to other crewmembers. A crewmember requesting a Bubba Review believes an unsafe situation has developed. Other crewmembers should attempt to resolve the conflict that has occurred by reexamining the present course of action. Through resolution of the conflict the current course of action can be continued or an alternative implemented.

A bubba review can be demanded at any time by any crewmember. A bubba review is composed of three questions:

- Sir, what is the decision?
- What are the consequences of the decision?
- Is there a new, alternative, better decision?

A bubba review causes a more open and complete decision making process. The completion of the review puts relevant issues in the open and allows a decision to be made based on issues identified by everyone. Another Bubba Review benefit is the effect of informing everyone on the aircraft the current course of action. Seminar participants are encouraged to write the synergy formula on one side of a note card and the three Bubba Review questions on the other side. The card should be kept in the individual's inflight checklist for immediate reference.

E. ACT EFFECTIVENESS CRITERIA

The driving force for widespread implementation of ACT and justification for its continued development is preservation of lives and assets. The criteria for determining if that goal is occurring are not easily measured. Number of mishaps per one hundred thousand flight hours, is the most popular criteria used in assessing effectiveness of Naval Aviation safety. For the year 1991 the mishap rate for Naval Aviation was 2.91 per 100,000 flight hours (Borowsky, 1990). Statistically, that number is very low relative to the number of hours flown. Since mishaps for some aircraft are infrequent events, measurement of mishaps per hours flown can be greatly affected by chance. A few chance incidents can greatly affect the mishap rate (Helmreich, Chidester, Foushee, Gregorich, Wilhelm 1989). A mid air collision of two aircraft or the crash of a formation flight define a single event that would skew the mishap rate figure. Only by observing mishap rates over a long period of years could any distinct trend be determined. Claims of immediate reductions in mishap rates via ACT may be premature. Since organizations

cannot continue a program such as ACT for an extended period on a trial basis, short term measures of program effectiveness are necessary for justification and further implementation.

To provide more immediate and valid measures of ACT effectiveness, Helmreich, Foushee, and Wilhelm (1989) have developed methods of assessment that can be applied. Instead of one measure, multiple measures are recommended. Three indicators are suggested including:

- Outcome Measures
- Process Measures
- Moderator Factors

The implementation of ACT should have observable effects. These effects are called outcome measures and include incidents where ACT training prevented a mishap, changes in crew coordination attitudes/abilities and a favorable response by crew members towards ACT (Helmreich, Foushee, and Wilhelm, 1989). Process measures are actual changes in execution briefing, preflight, flight and postflight evolution caused by implementation of ACT procedures. Process measures represent the implementation of ACT concepts into normal operating procedures. Moderator factors are composed of human and material resources and include organizational support and environmental factors that affect implementation of ACT. The implementation of ACT demands change from those involved. To overcome the resistance to change inherent in large organizations, moderator factors must support ACT. Success or failure of an ACT program can be determined by the moderator factors.

F. COCKPIT MANAGEMENT ATTITUDES QUESTIONNAIRE

The data set utilized to provide an analytical basis for this report is derived from the Cockpit Management Attitudes Questionnaire [(CMAQ), (Helmreich, Wilhelm, Gregorich, 1988), (Appendix A)]. Based on a study of 60 aviation mishaps occurring from 1968-1976 (Cooper, Lauber, 1980) five common errors related to crew coordination were identified including:

- Preoccupation with minor technical problems
- Inadequate leadership
- Failure to delegate tasks and assign responsibilities
- Failure to set priorities
- Failure to communicate intent and plans

The crew coordination attitudes necessary to prevent a reoccurrence of these failures were determined. The attitudes were compiled into a survey with a corresponding scale to allow the degree of concurrence of disagreement expressed by a respondent. The survey was titled The Cockpit Management Attitudes Questionnaire (CMAQ). An updated format is widely used for civil and military analysis of ACT effectiveness (Gregorich, Helmreich, Wilhelm, 1989). Responses to CMAQ survey questions can be analyzed by statistical methods to determine effects ACT training. The degree of concurrence or disagreement with survey questions indicates disposition towards attitudes critical to flight safety.

Trends can be expected in responses to the CMAQ. Organizations whose aircraft and mission are conducive to ACT implementation score more favorably to survey responses. For multi-crewed aircraft (P-3), safety and mission effectiveness are positively correlated to crew coordination ability. For single piloted aircraft (F-18), the potential benefit of crew coordination is

less as safety and mission effectiveness are often dependent upon one individual. This does not imply that pilots of single seat aircraft cannot benefit from ACT. Often pilots of single seat aircraft work in coordination with other aircraft and personnel external to their platform. History effects explain that aircrew members who have long term exposure to ACT respond differently than those who don't. Exposure to formal and informal training methods eventually causes increased awareness and acceptance of ACT (Gregorich, Helmreich, Wilhelm 1990).

The survey was modified for P-3 ACT so that question terminology would be compatible with P-3 aircrews. For example, instead of referring to the first pilot and load master the P-3 CMAQ version referred to the Plane Commander and Flight Engineer. Modification of question terminology was done so that original concepts remained intact. The P-3 seminar is not designed to teach directly to the CMAQ survey. Some CMAQ concepts are directly covered by the P-3 seminar, others are indirectly addressed and some are not reviewed at all. Only the portion of the survey designed to measure attitudes, is addressed in this thesis.

The ability to change attitudes is an important measure of the effectiveness of the P-3 ACT seminar. The CMAQ has been widely used in aviation training as a valid measure of attitudes affecting crew coordination. Policy makers can use this CMAQ analysis to guide the future of P-3 ACT. This thesis contributes to the knowledge necessary to direct the future of P-3 ACT.

The fit of ACT as a valuable part of a much larger aviation safety program, can be measured by CMAQ results. Failure of P-3 ACT to provide

useful training would indicate the need for a different approach to imparting crew coordination knowledge. Success of P-3 ACT would indicate that the present seminar format is accomplishing the objective of changing attitudes. An outcome between the two extremes would indicate a need for refining current efforts.

Crew coordination training programs vary according to the needs of an organization and its users. Concepts and methods of instruction can be varied to meet the needs of a group. The P-3's diverse group of crewmembers presents a challenge in developing a course appropriate for all crewmembers. Crewmembers differ by aircrew position, P-3 flight hours, years military, age and other variables. The degree to which the challenge of diversity is addressed can be measured by the uniformity of CMAQ responses.

If P-3 ACT is designed considering aircrew diversity, CMAQ responses will be similar across the groups. If P-3 ACT is less effective for particular sub-groups they will respond differently from the norm. To address requirements of a group that responds differently to ACT many options exist. The course could be amended for the entire group. The course could be amended and taught separately for the group with different responses. Lastly, ACT could be discontinued for the group responding below the norm. Ideally, all groups respond the same regardless of their crew position or military background.

G. P-3 AIRCREW COORDINATION TRAINING

This thesis does not represent the first research effort into P-3 Aircrew Coordination Training. John Wilhelm and Robert Helmreich of the University of Texas at Austin prepared a report as part of the NASA-University of Texas cooperative inquiry into Cockpit Research Management Training (Wilhelm, Helmreich, 1990). One aspect of their report, published in March of 1990, analyzed crewmembers' feelings towards ACT as determined by responses to the Cockpit Management Attitudes Questionnaire (Helmreich Wilhelm, Gregorich, 1988). Responses to the following questions and statement were analyzed:

- Overall, how useful did you find the training?
- How important is recurrent training in aircrew coordination?
- ACT has the potential to increase safety and crew effectiveness.
- Will the training change your behavior on the flightdeck?

Response options included:

- A Waste of Time
- Slightly Useful
- Somewhat Useful
- Very Useful
- Extremely Useful

90 percent of the participants found the course to be "very useful" or "extremely useful." 80 percent believed recurrent training is "very useful" or "extremely useful." 86 percent agreed strongly with the statement that "ACT has the potential to increase safety and crew effectiveness." 67 percent believed a "moderate" or "large" change in their behavior would occur as a result of the course. The research also included an analysis of participant opinions of each module of the course. Overall, all modules were thought to

be useful by the majority of participants. Acceptance of the usefulness of P-3 ACT was established for both officers and enlisted personnel.

In their report Wilhelm and Helmreich provide a positive answer to the question; Will crewmembers have favorable feelings towards the concepts and theory that are the basis for ACT? However, proof that ACT is liked by those who attend is not proof that positive attitude changes have occurred. The next step in the analysis and the purpose of this thesis is to determine if ACT has changed attitudes towards flight safety. Utilizing a section of the CMAQ separate from that used by Wilhelm and Helmreich, perceived attitude changes can be measured. Portions of the Cockpit Management Attitudes Questionnaire are designed to identify the attitude of the person taking the survey. P-3 ACT seminar participants were asked to complete the questionnaire before and immediately after the seminar. Changes in before and after questionnaire responses are indicative of an attitude change. If attitudes can be changed the course is serving its purpose of creating a more safe flying environment for the aircrews.

H. ORGANIZATIONAL/INDIVIDUAL REACTION

1. Resistance to Change

Acceptance of the need for change through ACT requires agreement that past patterns of behavior were less than adequate. P-3 squadrons are heavily tasked with training and operational requirements and can only devote limited time to additional training. Their demanding schedule often requires extended working hours and work on weekends. Participation in ACT may require a crewmember with years of experience and thousands of

mishap free flight hours to add to an already busy work schedule. To achieve ACT goals, resistance to change due to time constraints and other reasons has to be overcome.

The first step in overcoming resistance, is to identify a clear need for change. For ACT, the need for change is a need for preservation of lives and aircraft. This need may not be seen as a high priority for many P-3 crewmembers. The length of P-3 service for the crewmembers surveyed for this thesis was less than 5 years. During their time of P-3 experience, few accidents have occurred. The excellent safety record of the P-3 relative to other Naval aircraft may promote a false sense of security. The ACT program must first establish with participants the need for change based on past mishaps that have occurred and the potential of this program to prevent further mishaps.

The three-step process of crew coordination behavior change requires unfreezing of the present behavior pattern, moving to a new behavior pattern and refreezing desired behaviors (Lewin, 1958). The VP-31 course unfreezes present behavior through education of seminar participants. A review of P-3 and other crew coordination failures that have lead to mishaps, illustrates room for improvement. Movement to new behavior patterns is accomplished via knowledge and skills imparted through facilitators. Refreezing of desired behavior is accomplished through role play exercises where ACT skills are utilized by aircrew and then reviewed on video tape. The participation of senior crewmembers in the role play exercises is key to the acceptance of ACT concepts by junior personnel. Through their participation, senior personnel provide support for the legitimacy of the ACT

concepts. If the three-step change process has been successful new behaviors will be utilized during subsequent flights.

To achieve the change, someone is required to serve as the change agent (Sziligy, Wallace, 1987). The change agent should be someone not bound by tradition, culture or the politics of an organization. This person must offer new ideas, viewpoints and perspectives. The change agent must have support from organizational leadership and be able to gain the trust of those for whom change is required. The change agent for P-3 ACT is Dr. Henry H. Smith of VP-31. As a civilian working for the Navy, Dr. Smith is outside the lines of authority affecting crewmembers. He has been involved in the ACT field of study since 1985. As a retired Navy Captain and an aviator with thirty plus years of experience, he is knowledgeable about flight operations and has sufficient status among aircrews to serve as a change agent for implementing ACT.

Implementation of P-3 ACT has been accomplished with the awareness that resistance to change is expected. The primary means of overcoming resistance is the validity and utility of the material to crewmembers. Change will occur if the material is useful. Also, selection of a credible change agent has provided the best opportunity for course concepts to be heard and understood.

2. The Boomerang Effect

Implementation of ACT into military aviation is not universally supported. For example, a P-3 flight engineer who has accumulated thousands of P-3 hours may not see a need to integrate new ideas into present methods of managing a cockpit. A P-3 ordanceman may feel that his

opportunity to affect safety of flight related scenarios is limited and his opinion is not necessary or desired by the pilot or flight officer. These and other aircrew who attend ACT seminars may have negative reactions to the material presented.

A report on the Negative reaction phenomenon, *When Training Boomerangs* (Helmreich, Wilhelm, 1989), identifies a sub-group likely to have a negative reaction to ACT. The group is distinct not by the experience level or aircraft flown but by the personality type. Via factor analysis of the CMAQ, a group of individuals weak in both instrumental and expressive personality traits were identified. This group was prone to significant negative reaction to CMAQ communication and coordination related questions. ACT course concepts emphasize the importance and necessity of being a vocal and involved member of a crew. For this personality group these concepts conflict with established behavior patterns.

The strength of negative reaction can be influenced by another factor, group dynamics. The effect of group dynamics influenced the degree a seminar was good or bad as seen by participants. A successful ACT seminar requires an engaged, participative crew focused on the material being presented. Many outside influences beyond those that the facilitators control can cause a seminar to fall short of this goal. When a seminar does not captivate the crew, the weak instrumental and expressive personalities are much more likely to reject material being presented. ACT can cause attitudes to shift opposite of the desired direction for a distinct group of individuals.

P-3 ACT Facilitator training identifies the possibility of a negative reaction occurring. Facilitators are trained to identify aircrew who withdraw

from discussion or question the course content. Objections to the course concepts are encouraged to allow discussion among the group. Concepts are presented with "take it or leave it" option. Some will find ACT more useful than others. Even those who feel the course is of no use to them, have agreed that the course is useful to others (Smith, 1992). Boomerang individuals would be indicated in the CMAQ survey results by a shift in attitudes opposite from the desired direction.

The boomerang effect and other effects of ACT can be measured by the CMAQ. How much change has occurred in attitudes of crewmembers can be determined through analysis of CMAQ data. The P-3 ACT data base is a resource for measuring attitudes of those who completed the seminar.

III. DATA AND METHODOLOGY

A. DATA SET

A subset of the CMAQ contains thirty-two questions designed to measure an individual's attitude towards crew coordination issues. For each of 1,200 seminar participants, the CMAQ was administered just prior to and immediately after seminar completion. The sample of 1,200 represents approximately sixty percent of the total population who have completed the seminar. The data were screened based upon the criteria explained in part B of this chapter. The data were collected between June of 1988 and August of 1991.

Survey results were tabulated by Dr. John Wilhelm, University of Texas at Austin, and transferred to the Naval Postgraduate School mainframe computer. The data set has been modified to allow completion of this research. Personality measures and narrative comments have been removed as they are beyond the scope of this report. The data set is now limited to seventy-one response variables for each seminar participant including:

- Thirty-two preseminar attitude responses
- Thirty-two postseminar attitude responses
- Seven aircrew positional/experience demographic information variables

B. FILTERING OF DATA

Once the data file was loaded to the mainframe computer several actions were taken to ensure inaccurate data were filtered out. Data anomalies could

have occurred when surveys were completed, assembled into a data base or by other causes. Data were screened to ensure the analysis could utilize information representative of P-3 aircrews. The following steps were taken to screen the data:

- The CMAQ allows a response range of one through seven. Only those responses within this range were considered.
- Observations with missing values in the survey responses were not considered in the analysis.
- Number of hours with assigned crew was limited to 2000.
- Number of P-3 flight hours was limited to 10,000.
- Maximum age respondents was limited to a maximum of 45.
- Years in military service was limited to a maximum of 25.

Limiting of responses by the above standards is intended to provide a population sample most representative of P-3 aircrews assigned to squadrons at the time the surveys were completed. Initially, 1,200 observations were screened to determine their utility for analysis. After application of the previously explained measures, the group was narrowed to 573 observations. The primary reason for exclusion in the analysis is failure to correctly fill out the survey. CMAQ responses out of the 1-7 allowable range and demographic data not consistent with reasonable crewmember profiles eliminated some from inclusion. Seminar facilitators labeled some seminars as particularly good and others as particularly bad. No effort was made to screen out seminars based upon the level of success measured by the facilitator's evaluation. By including both good, bad and average seminars the analysis should reflect the overall program effects.

C. RESPONDENT DEMOGRAPHIC INFORMATION

The survey respondents represent the current pool of personnel the Navy has assigned operating P-3 aircraft in active duty squadrons. Variation in the demographic information is caused by organizational factors. All crew have differences in levels of experience based upon the years in the service and years of flying duty. Table 4.1 provides data on the respondents grouped by crew position. For each crew position provided are: hours assigned to crew (HRSCR), hours of P-3 flying (HRSP3), total flight hours (FLTHR), years of military service (YRSMIL), and age (AGE).

TABLE 3.1 DEMOGRAPHIC DATA FOR PERSONNEL INCLUDED IN CMAQ ANALYSIS

	AVERAGE VALUES BY CREW POSITION				
POSITION	HRSCR	HRSP3	FLTHR	YRMIL	AGE
PLANE CMDR.	195	1544	2106	8.9	34
SECOND PILOT	242	555	892	5.0	31
THIRD PILOT	97	240	433	3.5	28
FLIGHT ENGR.	316	2416	2579	10.9	29
NAVIGATOR	162	630	829	5.3	29
TACTICAL COORD.	188	1544	1700	7.8	33
SENSOR 1	290	1664	1766	8.1	28
SENSOR 2	150	694	633	4.3	26
SENSOR 3	283	1562	1695	6.1	28
INFLIGHT TECH.	333	1192	1160	6.6	30
ORDINANCE	345	1091	1152	5.8	27
GROUP AVERAGE	244	1360	1562	7.2	30

Source: Data derived from the P-3 CMAQ survey.

D. HYPOTHESIZED ATTITUDE CHANGE MODEL

This report will determine if attitude changes have occurred as measured by the pre and post seminar CMAQ. Figure 3.1 provides a model of the process utilized to conduct this analysis. Initial seminar responses indicate preseminar attitudes towards concepts that make-up each CMAQ question. Initial predisposition is a result of an individual's knowledge, attitudes and

skill. Individuals are predisposed to certain attitudes as a result of experiences in the past. A difference in the responses indicates effects of ACT training on the respondent. The frequency and significance of changes in responses may reveal patterns associated with a particular CMAQ questions or a group of respondents.

POST-SEMINAR		PRE-SEMINAR		CHANGE
ATTITUDE	-	ATTITUDE	=	CAUSED
RESPONSE		RESPONSE		BY ACT

Figure 3.1 Hypothesized Measure of Attitude Change

ACT seminar discussion is designed to create an increased awareness of crew coordination issues and promote a self-examination of existing attitude sets. Desirable and undesirable attitudes are explained by facilitators and demonstrated in role play activities. ACT is intended to reinforce desirable attitudes and eliminate undesirable tendencies. Participants who discover in themselves an undesirable attitude trait have a choice of reactions. The desirable reaction is for the individual to change his attitude to be more consistent with effective crew coordination. All phases of the seminar address attitudes either directly or indirectly through concepts taught. The seminar is designed to cause change in attitudes where change is necessary.

Immediately following the seminar, before the participants depart, the CMAQ is re administered. CMAQ responses now become a measure of the attitude set an individual started the seminar with modified by changes caused by ACT. This report is focused on identifying changes that have taken place as a result of ACT.

E. ANALYTICAL PROCEDURES

1. Hypothesis Tests For Means of Paired Samples

An examination of changes in attitudes as measured by the CMAQ was conducted to determine changes caused by ACT. Thirty-two preseminar and postseminar CMAQ responses were compared for the group and for subgroups of respondents. Analyses included input only from those respondents not screened out by methods explained earlier in this report. T-tests applied to preseminar and postseminar responses were used to determine if changes in attitudes had taken place and if the changes were statistically significant. T-tests by aircrew position were used to determine if ACT was more effective for particular subgroups.

Preseminar and postseminar CMAQ scores are paired samples. By pairing the samples an accurate measurement of seminar effects can be obtained (Weiss, Hassett, 1991). The difference between the two responses is the paired difference and is defined as:

- $d = x_2 - x_1$

where,

- x_2 = postseminar and x_1= preseminar response

The null hypothesis for the T-test analysis is that the difference between paired samples is zero. The alternative hypothesis is that the difference is greater than or less than zero. A significant change away from zero in the desired direction, indicates an attitude change has occurred. The null (H_o) and alternative (H_a) hypotheses are defined as:

- H_o: $\mu 1 = \mu 2$
- H_a: $\mu 1 > \mu 2$ or $\mu 1 < \mu 2$

By evaluating whether a change in response has occurred at the 5 percent significance level, the standard by which an attitude change has occurred is determined. The t-tests applied were one tailed. The direction of the desired attitude shift is dependent upon the CMAQ question. Questions for which a positive shift is desired were right tailed. Questions for which a negative shift is desired were left tailed. Both tests were done at the 5 percent significance level as signified by:

- $\mu = .05$

For this analysis, the significance level of 5 percent was used to determine if the null hypothesis was accepted or rejected. Testing at the 5 percent level is a commonly used value although more or less stringent criteria can be applied. When all participants were analyzed together the critical value of t is 1.645. For subgroups of twenty-nine or less the critical value increases. In this thesis group size exceeded twenty-nine for all groups allowing the same critical value to be used for all t-test analyses. The critical value is:

- $t_{0.05} = 1.645$ if $n > 29$

A hypothesis test can be completed utilizing the mean of the paired differences, the standard deviation of the paired differences and a sum of observations utilized. The result of the relationship of these variables is a test statistic that can be compared against the critical value. If the test statistic does not exceed the critical value the null hypothesis is accepted. If the test statistic exceeds the critical value the null hypothesis is rejected. The test statistic is determined by:

- $t = \dfrac{d}{s_d / n}$.

2. Correlation Analysis

A correlation analysis of changes in survey responses and demographic data was used to indicate the relationship between these variables and the responses given. Years of flying and military experience may correlate with an increased or decreased acceptance ACT concepts. Correlation analysis can detect any linkage between CMAQ responses and flight hours, P-3 experience, age and years of military service. The Pearson product moment correlation coefficient is used to provide the level of correlation between CMAQ responses and individual characteristics (Weiss, Hassett, 1991). The value of the correlation coefficient (r) will lie between -1 and 1. Values close to -1 or 1 indicate strong correlation. Values close to zero indicate weak correlation. Correlations were computed via the following formula:

- $r = \dfrac{S_{xy}}{S_{xx}S_{yy}}$

where

- $S_{xx} = \sum x^2 - (\sum x)^2 / n$
- $S_{xy} = \sum xy - (\sum x)(\sum y) / n$
- $S_{yy} = \sum y^2 - (\sum y)^2 / n$

Correlation analysis can identify strengths or weaknesses in ACT training. If certain attributes of entering experience or qualification level affect ACT outcomes, those attributes will result in exceptional correlation scores. Correlation analysis should indicate the effectiveness of training for different sub-groups of participants.

IV. RESULTS AND DISCUSSION

This section describes the results of the analyses undertaken to determine if attitude changes occurred as a result of ACT for P-3 aircrews. The primary research objective is to apply statistical analysis techniques to the CMAQ data base and interpret results. Results for group and sub-groups therein will be determined.

A. T-TEST ANALYSIS

Before and after seminar survey responses are the focus of this thesis. Table 4.1 presents analysis results of preseminar and postseminar responses for the entire group of respondents. Results for sub-groups by aircrew position are in appendix B (1-11). Differences between responses before and after the seminar are indicative of attitude changes. For half of the CMAQ responses (Questions 2,3,4,6,7,8,10,12,14,15,16,20,21,22,23,28) a positive value shift in survey response is desirable. For other survey responses (Questions 1,5,9,11,13,17,18,19,24,25,26,27,29, 30,31,32) a negative value shift is the desired outcome. The difference in the desired direction is caused by survey question wording. Some questions evaluate concurrence with desirable attitudes, others evaluate level of disagreement with undesirable tendencies. This analysis will focus on changes in survey responses to evaluate their frequency and significance. The analysis is conducted for the entire group and for sub-groups.

T-tests of the difference between the thirty-two preseminar and postseminar CMAQ responses indicate attitude changes caused by ACT.

Where the test statistics did not exceed the critical value no change in attitude was judged to have occurred. When the test statistics exceeded the critical value an attitude change was judged to have occurred. For each individual thirty-two possible changes could have occurred on the CMAQ. Based on the 5 percent significance level standard the total number of changes occurring was determined. Three possible outcomes existed for each CMAQ response:

- An attitude shift in the desired direction
- No attitude change
- An attitude change opposite the desired direction

Table 4.1 provides the combined t-test results for all crew positions grouped together. The combined t-test is useful for determining the impact of ACT on the group as a whole. The methodology used to attain the results in table 4.1 is explained in chapter III section E of this report. The last column in table 4.1 indicates the probability value and whether or not the value was significant.

TABLE 4.1 GROUP CMAQ PRESEMINAR (X1) AND POSTSEMINAR (X2) SURVEY MEANS, CHANGE, T VALUE AND T-TEST RESULTS

CMAQ	X1 MEAN	X2 MEAN	IDEAL SHIFT	ACTUAL CHANGE	T VALUE	PROBABILITY VALUE
1	4.40	3.68	-	-.717	11.943	.0001 *
2	5.67	5.95	+	.283	5.500	.0001 *
3	5.57	5.96	+	.391	7.940	.0001 *
4	4.36	4.30	+	-.067	1.001	.3171
5	5.34	4.46	-	-.869	10.642	.0001 *
6	6.02	6.27	+	.248	6.013	.0001 *
7	6.73	6.76	+	.033	1.369	.1716
8	5.58	6.07	+	.476	10.417	.0001 *
9	5.82	5.30	-	-.519	9.634	.0001 *
10	6.32	6.46	+	.136	3.660	.0003 *
11	3.28	2.42	-	-.855	10.625	.0001 *
12	5.75	5.96	+	.216	4.987	.0001 *
13	4.32	4.41	-	.089	1.428	.0001 *
14	5.02	6.03	+	1.016	14.717	.0001 *
15	2.85	2.90	+	.065	0.848	.3966
16	5.97	6.38	+	.395	8.290	.0001 *
17	4.11	3.83	-	-.276	4.568	.0001 *
18	2.18	2.26	-	.080	1.392	.1645
19	2.40	2.25	-	-.148	2.364	.0184 *
20	5.41	6.04	+	.640	9.961	.0001 *
21	6.51	6.66	+	.150	4.437	.0001 *
22	5.95	6.33	+	.377	7.937	.0001 *
23	5.82	6.13	+	.317	5.989	.0001 *
24	4.15	3.61	-	-.543	7.949	.0001 *
25	5.05	4.87	-	-.185	3.167	.0016 *
26	4.78	4.57	-	-.200	2.752	.0061 *
27	1.90	1.87	-	-.035	0.670	.5031
28	6.22	6.48	+	.260	5.394	.0001 *
29	2.08	1.72	-	-.361	7.101	.0001 *
30	2.48	2.24	-	-.240	4.532	.0001 *
31	2.02	1.72	-	-.297	5.708	.0001 *
32	1.22	1.24	-	.016	0.651	.5154

Source: Data derived from the P-3 CMAQ surveys.

* Indicates desirable attitude change occurred.

The combined group t-test indicated 25 desirable CMAQ changes out of 32 possible. Utilizing the entire group for the test, provides a much higher number of indicated attitude changes as compared to t-tests by sub-group. The higher number is caused by the combined effect of the group. A slight though insignificant change in attitude for a sub-group may become a significant change when all the groups share the same slight change in attitude. 25 out of 32 desirable shifts in attitude represent a change on 78 percent of the CMAQ questions.

Table 4.2 provides the T-test results for the entire survey group as indicated by table 4.1 and for sub-groups by aircrew position. Table 4.2 indicates the number of significant attitude changes occurring out of a total of thirty-two possible. Significant changes in attitudes for sub-groups were determined by the same method used in table 4.1 based on the results in appendix B 1-11.

TABLE 4.2 BREAKDOWN OF ATTITUDE CHANGES AS INDICATED BY A T-TEST OF PRE AND POST ACT SEMINAR CMAQ SURVEYS

	CMAQ RESPONSES		
GROUPING	DESIRABLE SHIFTS	NO CHANGE	UNDESIRABLE SHIFTS
ALL RESPONDENTS	25	7	0
PLANE COMMANDER	16	15	1
SECOND PILOT	7	25	0
THIRD PILOT	7	25	0
FLIGHT ENGINEER	16	16	0
NAVIGATOR	13	19	0
TACTICAL COORDINATOR	18	14	0
SENSOR ONE	10	22	0
SENSOR TWO	10	22	0
SENSOR THREE	11	21	0
INFLIGHT TECHNICIAN	14	18	0
ORDNANCE	11	21	0

Source: Derived from analysis of P-3 CMAQ data.

The results of t-test analyses as displayed in table 4.2 indicate that in many cases the null hypothesis that CMAQ scores are the same after the seminar, can be rejected. The range of significant desirable attitude shifts for all positions is 7 to 18 for the 32 CMAQ questions. A comparison of attitude changes is displayed in figure 4.2.

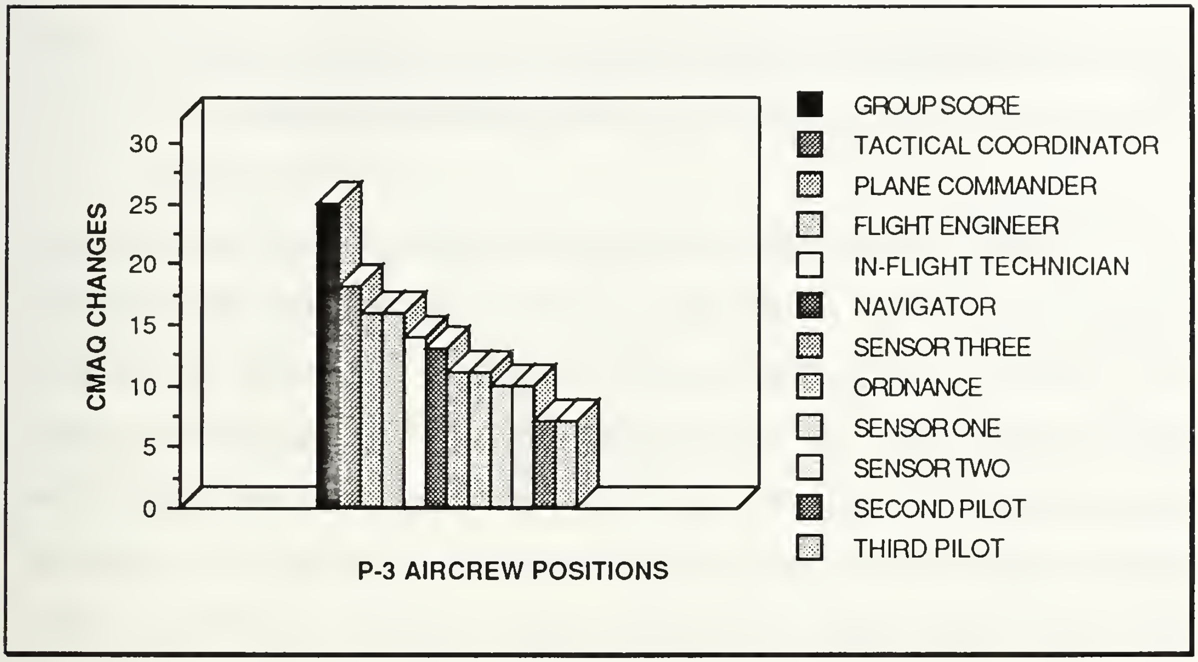

Figure 4.1 Favorable Changes in CMAQ Attitudes

B. INTERPRETATION OF T-TEST ANALYSIS

The CMAQ is an instrument for measuring concurrence with attitudes conducive to effective crew coordination. The method used to construct the CMAQ has provided a tool for measuring overall crew coordination awareness and potential. It was not designed to directly identify particular strengths or weaknesses in sections of P-3 ACT. The material in P-3 ACT does not directly address questions on the CMAQ. Within each CMAQ question are many crew coordination concepts and issues. Question by question analysis of CMAQ results does not allow a distinct understanding of thirty-two separate ACT concepts and issues. By looking at the combined CMAQ change for all thirty-two questions the effect of ACT can be seen. The results of the P-3 CMAQ have provided the change in CMAQ scores based on comprehensive change and not a question by question analysis. P-3 CMAQ t-

test results have resulted in the formation of three distinct groups. The three sub-groups are identified and explained in the following sections.

1. Sub-group One

Plane Commanders (16), Flight Engineers (16) and Tactical Coordinators (18) had the highest number of attitude shifts resulting from ACT training. A Plane Commander is primarily responsible for the safe completion of a flight. The Tactical Coordinator is responsible for successful completion of a mission. The flight engineer is responsible to the pilot for support in flight safety related issues. Successful completion of all three of these crew assignments is dependent upon effective crew coordination. These results indicate a positive relationship between responsibility for crew coordination and the impact of ACT.

2. Sub-group Two

Figure 4.1 indicates a similar level of attitude changes across sensor station operators, inflight technician and ordnanceman. For this group the average number of attitude response changes was 11.2 indicating that for over one third of the CMAQ responses an improvement on safety attitudes was achieved. During the conduct of a flight these crew positions can occasionally play a critical safety role during a flight. However, for most flights they are more likely to play minor role related to safety issues. To this group, ACT concepts are more likely to reflect a new way of thinking about their roles because their training places less emphasis on crew coordination and safety. This subgroup of the P-3 crew is mainly responsible for mission related aspects. The P-3 ACT course is designed to broaden utility of ACT from flight station personnel to include the all crewmembers. The number of positive

shifts occurring in this group supports the ACT principle that crew coordination is everyone's responsibility.

3. Sub-group Three

Second Pilots, Third Pilots and Navigators represent another subgroup of attitude shifts as measured by the CMAQ. A commonalty within this group is the accomplishment of tasks under the immediate direction of others on board the aircraft. The Second and Third Pilots perform their assignments under the immediate direction of the Plane Commander. The Navigator works under the supervision of the Tactical Coordinator. For all three crew positions, tasks, are to be carried out according to guidelines set by the Plane Commander or Tactical Coordinator. Crew coordination development and execution is a lessor role for this group. The lower number of shifts for Second Pilots, Third Pilots and Navigators as compared to their senior counterparts, could be reflective of a lessor crew coordination responsibility and authority.

C. CORRELATION ANALYSIS

Identification of subgroups for whom ACT is more or less effective, would be useful for understanding the effects of ACT. Perhaps ACT is not effective for sensor station operators who are less involved in safety issues. Possibly senior personnel will resist the new concepts and revised thinking that is part of ACT. Previous safety related programs focus on flight station personnel only whereas ACT has brought in all crew positions. Correlations were run on demographic variables and the difference scores between pre- and post- CMAQ responses. These analyses will help support or dispel these

and other questions regarding ACT and its relationship to demographic information included in table 3.1.

Correlation responses fall within a -1.00 to 1.00 range. Any value near these extremes can be evaluated for its implications for seminar design and teaching. Table 4.3 provides a correlation analysis for change in CMAQ score and four demographic variables including: hours assigned to crew (HRSCR), hours of P-3 flying (HRSP3), years of military service (YRMIL) and birth year (AGE) for the all respondents.

TABLE 4.3 CORRELATION OF CMAQ CHANGES AND DEMOGRAPHIC DATA CORRELATION VALUES

CMAQ CHANGE	HRSCR	HRSP3	YRMIL	AGE
1	.08	.08	–.02	–.04
2	.06	–.04	–.04	–.08
3	–.02	.06	.02	.01
4	.00	.00	.00	.00
5	–.01	.04	.07	.06
6	–.06	–.03	–.03	.00
7	.00	.00	–.04	.00
8	–.01	–.05	–.10	–.10
9	–.01	–.01	–.04	–.05
10	–.02	–.01	–.02	–.02
11	–.10	–.06	.04	.07
12	–.01	–.04	–.04	.00
13	.02	.00	.03	–.02
14	.08	–.06	–.03	–.02
15	.03	–.02	.03	.00
16	.05	.08	.07	.04
17	.05	.01	.05	.03
18	–.01	.04	.03	.00
19	–.06	.03	.02	.05
20	.03	–.02	.00	–.01
21	.10	.07	.07	.00
22	.06	.01	.01	–.01
23	–.04	.07	.08	.08
24	.03	.01	.06	.03
25	.05	.03	.09	.06
26	–.01	.04	.00	–.02
27	.03	.08	.02	.00
28	–.02	–.06	–.07	.06
29	–.03	.05	.07	.02
30	.00	–.08	–.02	–.03
31	–.07	–.03	.05	.05
32	.01	–.01	.00	.02

Source: Derived from analysis of P-3 CMAQ data.

No significant correlation exists between CMAQ response changes and the demographic variables as displayed in table 4.3. The highest correlation value in table 4.3 is .10. Even the highest value does not identify any strong correlation between attitude change and the demographic variables included in the analysis.

D. INTERPRETATION OF CORRELATION ANALYSIS

The CMAQ was not specifically designed to allow correlation of individual background data and changes in attitudes. Inability of the CMAQ to indicate correlation of individual data and changes in CMAQ response does not mean that another survey instrument could not demonstrate this relationship. Correlation of hours assigned to crew, P-3 flight hours, years in the military and age with the relatively small average change in CMAQ responses results in low correlation values. For all but one of the thirty-two CMAQ questions the average change in survey response was less than 1.0 for the group analyzed (table 4. 1). The small range of average change in survey response offers minimum opportunity for establishing a correlation with CMAQ score and the demographic variables used in the analysis. Based upon the change in CMAQ response that did occur, no significant correlation existed between change in response and individual characteristics.

Correlation analysis indicates CMAQ response is not a function of P-3 flight experience, hours assigned to a crew, years military, and age. Lack of strong correlation (table 4.3) indicates these variables do not significantly affect responses to the CMAQ. Attitude changes could not be predicted by an individual's experience level. Based on the correlation analysis, aircrew of

different experience levels react similarly to ACT. No experience level group is reacting significantly better or worse to the seminar. No change in the way ACT is designed or instructed is needed based upon years in the military, age, hours on a crew or P-3 flight hours.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. CMAQ T-test Results

P-3 ACT was successful in improving the attitudes of crewmembers who attended the seminar. The present format of the seminar is creating an understanding of attitudes necessary for effective crew coordination. Based on knowledge attained in the seminar, crewmembers are changing their CMAQ responses. The t-test results do provide evidence that attitudes are changing. P-3 CMAQ results indicate that movement away from attitudes that have caused mishaps in the past. Further, movement on CMAQ responses is substantial and is occurring for all crew positions. Additional analyses using the same methodology could provide a basis for evaluating the P-3 seminar relative to other programs.

Some differences existed by crew position in the number of changes that occurred on the CMAQ (table 4.2). Crewmembers in leadership roles were most likely change their attitudes as a result of ACT. Those less involved in managing crew coordination activity were less likely to indicate an attitude change. The value of ACT seems to be most appreciated by those who are normally responsible for implementing ACT concepts. Changes away from desirable crew coordination attitudes are not evident in the CMAQ analysis.

2. CMAQ Correlation Results

The existing course content and seminar format are uniformly effective across aircrew experience levels. The correlation analysis (table 5.2) fails to identify any anomalies associated with CMAQ response and the crewmember demographic variables. The seminar does not teach to a particular experience level group at the expense of others. Hours of P-3 flying, hours assigned to crew, years in the military and age were not useful in predicting changes in attitudes. The correlation analysis supports the concept of bringing in an intact combat aircrew for the seminar.

By attending ACT as a combat crew, a group attitude may be formed towards crew coordination. The group attitude towards ACT may result from the combined effects of individual attitudes. The group coordination attitude is important as the group will encounter challenges together. Knowledge of an individual member's attitude towards crew coordination can be used to make the group more effective under challenging flight scenarios. This analysis supports the present scheduling by complete combat aircrew as opposed to by aircrew position.

3. Program Effectiveness

P-3 ACT has substantive indications of being an effective program as measured by outcome, process and moderator criteria. Indicators include: CMAQ attitude changes, avoidance of a mid-air collision (Smith, 1992) and continued high-level organizational support. P-3 flight manuals now include ACT as a critical sub-area for success on the annual flight evaluation. To be designated as a qualified crewmember, crew coordination proficiency must be demonstrated. Integration of ACT into flight evaluations is an

indication of commitment to the program. The substantial dedication of resources over several years has allowed program development and implementation. Continued implementation of ACT will eventually allow the necessary time to evaluate ACT effects on P-3 mishap rates. In time the benefit of ACT could be put in terms of number of lives and aircraft saved.

B. IMPLICATIONS

The Naval Safety Center has identified crew coordination error as the number one causal factor in Naval Aviation mishaps. An increase in effective crew coordination capability creates the potential for reduction of crew coordination related mishaps. The P-3 ACT course is capable of improving crew coordination attitudes as measured by the CMAQ. Eventually a reduction in P-3 crew coordination related mishaps should occur if attitude changes seen here transfer to behavior changes on the job. An accurate measure of this reduction can only be made after sufficient time has taken place to account for the chance element that is present in tracking the occurrence of mishaps.

C. RECOMMENDATIONS

The initial analysis of the P-3 program completed in 1990 by Wilhelm and Helmreich (Wilhelm, Helmreich, 1990), determined that crewmembers believed P-3 ACT training was useful. This thesis indicates that in addition to finding the course useful, crewmembers attitudes are changed in a positive direction by the course. A follow-on thesis could attempt to determine if crew coordination concepts are being utilized.

Use of ACT could be determined by surveying seminar graduates and requesting them to document situations where ACT was used. The feedback from aircrew operators would be valuable in documenting the application of ACT during actual flight operations. Documentation of actual events could allow the determination of the effectiveness of separate ACT modules. The follow-on thesis or report could be constructed of case studies that emphasize the use of ACT during flight operations.

The CMAQ used to analyze the P-3 crewmember responses could be redesigned or expanded to take into account factors unique to Naval Aviation. The CMAQ was designed based on the analysis of civilian aviation incidents. Perhaps a similar study of Naval Aviation mishaps would reveal crew coordination concepts unique to Naval Aviation. A redesigned CMAQ based on crew coordination issues most relevant to Naval Aviation could provide a more useful measure. The present CMAQ is valuable in providing a standardized measure for the effectiveness of crew coordination training. A revised CMAQ modified for Naval Aviation could be used as a standard for crew coordination training.

The CMAQ should be revised so that all questions evaluate concurrence with desirable attitudes. At present the CMAQ measures concurrence with desirable crew coordination attitudes (Questions 2,3,4,6,7,8,10,12,14,15,16,20,21,22,23,28) and disagreement with undesirable attitudes (Questions 1,5,9,11,13,17,18,19,24,25,26,27,29, 30,31,32). Questions could be restructured so that for all questions a desirable shift in attitude occurs in the same direction on the survey scale. Analysis and presentation

of survey data would be more clear if all questions were consistent in evaluating concurrence with desirable attitudes.

The completion of ACT training brings the program to a transition point. The one-day seminar format for P-3 ACT has been presented to all Moffett Field California and Barbers Point Hawaii P-3 squadrons. The decision to continue or discontinue training must be made. If training is continued the new content and format must be determined. Reduced benefit may be realized by attending the same course a second time. A revised version of the course may need to be developed. A longitudinal study could determine the durability of the effects of ACT and the present need for continued training.

Options for continued ACT training include the use of simulator and flight training. Limited flight hours and simulator time make it unlikely that entire events could be exclusively dedicated to ACT training. A practical way of including ACT concepts as an integral part of flight and simulator events is via the evaluators who conduct these events. All P-3 flight crew personnel are required to pass an annual flight evaluation. The evaluators who conduct these events could provide the means for further ACT training. For this to occur, evaluators must first complete a follow-on ACT course that imparts to them a deeper understanding of ACT principles along with the ability to evaluate the crew coordination skills of others. The evaluators could then instruct and evaluate crew coordination as part of every flight or simulator event.

Aircrew Coordination Training is sponsored within the Navy for the purposes of achieving a reduced mishap rate. Avoidance of mishaps in part depends upon effective crew coordination. Effective tactical utilization of the

P-3 aircraft also demands effective crew coordination. The ability of P-3 ACT to enhance the tactical ability of a combat aircrew has not been determined. If ACT equally applies to tactical crew coordination the scope of the course may be expanded to enhance safety and tactical ability.

APPENDIX A. P-3 COCKPIT MANAGEMENT ATTITUDES

UT/NASA/Navy 5-89 QUESTIONNAIRE (CMAQ) Page 1

P-3 AIRCREW SURVEY

I. Patrol Crewmember Attitudes

As part of NASA sponsored research, we are collecting data on current attitudes in military operations. This survey measures your thoughts and feelings; it is not an assessment of your learning. All data will remain strictly confidential! The identification number allows us to relate your future surveys to this one.

Please answer by writing beside each item the number from the scale below that best reflects <u>your personal attitude</u>. Note: when we use the words "crew" or "crew members", we mean <u>everyone</u> on the aircraft unless otherwise noted.

******Scale******

1	2	3	4	5	6	7
Disagree Completely	Disagree Mostly	Disagree Somewhat	Neutral	Agree Somewhat	Agree Mostly	Agree Completely

_______ Strict utilization of the chain of command is essential for effective crew performance.

_______ Aircrew members should feel obligated to mention their own psychological stress or physical problems to other aircrew members before or during a mission.

_______ It is important for all crew members to provide constructive criticism about the procedures and techniques of others.

_______ I am more prone to make minor mistakes during periods of high workload than I am in routine mission situations.

_______ The PPC is primarily responsible for the safety of each mission.

_______ Each crew member should monitor other crew members for signs of stress or fatigue, and should discuss the situation with the crew member.

_______ Good communications and crew coordination are as important as technical proficiency for the safety of flight.

_______ Aircrew members should be aware of and sensitive to the personal problems of other crew members.

_______ The PPC should take control and fly the aircraft in emergency and non-standard situations.

_______ The pilot flying the aircraft should <u>verbalize</u> plans for procedures or maneuvers and should be sure that the information is understood and acknowledged by crew members affected.

_______ Copilots and other crew members should not question the decisions or actions of the PPC except when these actions threaten the safety of the flight.

_______ Crew members should alert others to their actual or potential work overloads.

_______ Even when fatigued, I perform effectively during critical flight maneuvers.

_______ PPC's should encourage copilots, flight engineers, and other crew members to question procedures during normal flight operations and in emergencies.

_______ There are no circumstances (except total incapacitation) where the copilot should assume command of the aircraft.

_______ A debriefing and critique of procedures and decisions after each mission is an important part of developing and maintaining effective aircrew coordination.

*******Scale******

1	2	3	4	5	6	7
Disagree Completely	Disagree Mostly	Disagree Somewhat	Neutral	Agree Somewhat	Agree Mostly	Agree Completely

_______ My performance is not adversely affected by working with an inexperienced or less capable crew member.

_______ Overall, successful mission accomplishment is primarily a function of the aircraft commander's flying proficiency.

_______ Correcting the procedures and techniques of others should be avoided since it can lead to tensions between crew members.

_______ Crew members should voice their concerns even if they are contrary to decisions which have alredy been made.

_______ The pre-mission aircrew briefing is important for safety and for effective crew management.

_______ Effective crew coordination requires crew members to take into account the personalities of other crew members.

_______ All crew members should share responsibility for prioritizing activities in high workload situations.

_______ A truly professional aircrew member can leave personal problems behind when flying a mission.

_______ My decision making ability is as good in emergencies as in routine mission situations.

_______ Training seldom interferes with safe and effective mission accomplishment.

_______ Leadership of the aircrew team is expected to come solely from the PPC.

_______ Enlisted crewmembers' questions and suggestions should be considered by the flight deck.

_______ When joining a crew for the first time, a new crew member should not offer suggestions or opinions unless asked.

_______ It is better to let someone do their job the way they are used to rather than offering what you believe to be a better solution.

_______ Because flight engineers have no pilot training, they should limit their attention to airplane systems.

_______ PPCs who accept and implement suggestions from the crew are lessening their stature and reducing their authority.

APPENDIX B-1. T-TEST RESULTS FOR CMAQ RESPONSES

TABLE B-1. PLANE COMMANDER T-TEST RESULTS

POSIT=1

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	96	-0.813	0.138	-5.906	0.0001
QDIFF2	96	0.292	0.099	2.939	0.0041
QDIFF3	96	0.271	0.120	2.260	0.0261
QDIFF4	96	-0.083	0.142	-0.588	0.5581
QDIFF5	95	-1.147	0.183	-6.261	0.0001
QDIFF6	96	0.219	0.093	2.359	0.0204
QDIFF7	96	0.042	0.051	0.815	0.4171
QDIFF8	96	0.354	0.104	3.417	0.0009
QDIFF9	96	-0.573	0.137	-4.178	0.0001
QDIFF10	96	0.125	0.080	1.561	0.1219
QDIFF11	96	-0.573	0.163	-3.506	0.0007
QDIFF12	96	0.167	0.086	1.940	0.0554
QDIFF13	96	-0.073	0.155	-0.471	0.6387
QDIFF14	95	0.863	0.133	6.505	0.0001
QDIFF15	95	0.105	0.167	0.630	0.5299
QDIFF16	95	0.400	0.123	3.256	0.0016
QDIFF17	96	-0.385	0.160	-2.413	0.0178
QDIFF18	96	-0.010	0.109	-0.095	0.9243
QDIFF19	96	-0.063	0.109	-0.575	0.5664
QDIFF20	96	0.708	0.125	5.680	0.0001
QDIFF21	96	0.115	0.089	1.292	0.1995
QDIFF22	96	0.156	0.110	1.419	0.1593
QDIFF23	96	0.458	0.126	3.625	0.0005
QDIFF24	96	-0.396	0.151	-2.628	0.0100
QDIFF25	96	-0.021	0.132	-0.158	0.8746
QDIFF26	95	-0.053	0.173	-0.305	0.7614
QDIFF27	96	-0.052	0.103	-0.506	0.6142
QDIFF28	96	0.083	0.090	0.929	0.3551
QDIFF29	96	-0.281	0.135	-2.088	0.0394
QDIFF30	96	-0.125	0.114	-1.097	0.2756
QDIFF31	96	-0.094	0.099	-0.943	0.3481
QDIFF32	96	0.115	0.059	1.942	0.0551

TABLE B-2. SECOND PILOT T-TEST RESULTS

POSIT=2

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	23	-0.870	0.363	-2.397	0.0255
QDIFF2	23	0.174	0.279	0.624	0.5390
QDIFF3	23	0.522	0.266	1.963	0.0624
QDIFF4	23	0.522	0.258	2.021	0.0557
QDIFF5	23	-0.435	0.506	-0.859	0.3996
QDIFF6	23	0.304	0.171	1.775	0.0897
QDIFF7	23	0.000	0.089	0.000	1.0000
QDIFF8	23	0.348	0.195	1.785	0.0881
QDIFF9	23	-0.565	0.287	-1.970	0.0616
QDIFF10	22	-0.136	0.119	-1.142	0.2664
QDIFF11	23	0.087	0.503	0.173	0.8642
QDIFF12	23	0.478	0.226	2.121	0.0455
QDIFF13	23	0.304	0.347	0.877	0.3897
QDIFF14	22	1.182	0.346	3.417	0.0026
QDIFF15	22	0.045	0.392	0.116	0.9088
QDIFF16	22	0.136	0.136	1.000	0.3287
QDIFF17	23	-0.478	0.349	-1.369	0.1848
QDIFF18	23	0.261	0.191	1.367	0.1855
QDIFF19	23	0.130	0.334	0.390	0.7003
QDIFF20	22	0.727	0.349	2.082	0.0497
QDIFF21	23	0.130	0.114	1.141	0.2660
QDIFF22	23	0.130	0.170	0.768	0.4509
QDIFF23	23	0.391	0.224	1.744	0.0951
QDIFF24	23	-0.783	0.259	-3.023	0.0063
QDIFF25	23	-0.348	0.324	-1.073	0.2951
QDIFF26	22	-0.727	0.256	-2.837	0.0099
QDIFF27	23	-0.304	0.284	-1.071	0.2958
QDIFF28	23	0.000	0.126	0.000	1.0000
QDIFF29	23	-0.304	0.255	-1.194	0.2451
QDIFF30	23	-0.130	0.211	-0.617	0.5435
QDIFF31	23	-0.043	0.172	-0.253	0.8027
QDIFF32	23	0.043	0.076	0.569	0.5753

TABLE B-3. THIRD PILOT T-TEST RESULTS

POSIT=3

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	34	-1.000	0.223	-4.476	0.0001
QDIFF2	34	0.176	0.107	1.643	0.1098
QDIFF3	34	0.441	0.175	2.520	0.0167
QDIFF4	34	-0.176	0.225	-0.783	0.4390
QDIFF5	34	-0.971	0.314	-3.086	0.0041
QDIFF6	34	0.265	0.195	1.358	0.1836
QDIFF7	34	-0.118	0.092	-1.277	0.2107
QDIFF8	33	0.182	0.171	1.063	0.2959
QDIFF9	34	-0.882	0.188	-4.701	0.0001
QDIFF10	34	-0.029	0.161	-0.183	0.8559
QDIFF11	34	-0.735	0.314	-2.342	0.0254
QDIFF12	34	0.206	0.157	1.314	0.1980
QDIFF13	34	-0.029	0.237	-0.124	0.9019
QDIFF14	32	0.906	0.285	3.177	0.0034
QDIFF15	32	0.219	0.268	0.815	0.4213
QDIFF16	32	0.281	0.197	1.428	0.1632
QDIFF17	34	-0.500	0.265	-1.890	0.0675
QDIFF18	34	-0.059	0.286	-0.206	0.8384
QDIFF19	34	0.176	0.221	0.797	0.4309
QDIFF20	34	0.118	0.270	0.436	0.6654
QDIFF21	34	-0.029	0.099	-0.297	0.7680
QDIFF22	34	0.265	0.154	1.719	0.0951
QDIFF23	34	0.412	0.257	1.601	0.1189
QDIFF24	34	-0.471	0.268	-1.757	0.0882
QDIFF25	34	-0.353	0.289	-1.221	0.2308
QDIFF26	33	-0.364	0.225	-1.614	0.1165
QDIFF27	34	0.059	0.215	0.274	0.7861
QDIFF28	33	0.303	0.119	2.545	0.0159
QDIFF29	34	-0.353	0.179	-1.977	0.0565
QDIFF30	34	0.029	0.143	0.206	0.8384
QDIFF31	34	-0.206	0.125	-1.646	0.1093
QDIFF32	34	-0.029	0.067	-0.442	0.6615

TABLE B-4. FLIGHT ENGINEER T-TEST RESULTS

POSIT=4

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	63	-0.444	0.182	-2.440	0.0175
QDIFF2	63	0.048	0.162	0.293	0.7702
QDIFF3	63	0.349	0.150	2.322	0.0235
QDIFF4	63	-0.254	0.235	-1.080	0.2843
QDIFF5	63	-0.762	0.269	-2.828	0.0063
QDIFF6	63	0.032	0.104	0.306	0.7603
QDIFF7	63	0.016	0.089	0.178	0.8591
QDIFF8	63	0.317	0.126	2.527	0.0141
QDIFF9	63	-0.603	0.144	-4.187	0.0001
QDIFF10	63	-0.127	0.110	-1.158	0.2514
QDIFF11	63	-0.492	0.223	-2.209	0.0309
QDIFF12	63	0.238	0.127	1.868	0.0664
QDIFF13	63	0.460	0.184	2.507	0.0148
QDIFF14	61	0.672	0.237	2.837	0.0062
QDIFF15	61	0.213	0.197	1.081	0.2840
QDIFF16	61	0.426	0.116	3.687	0.0005
QDIFF17	63	-0.032	0.207	-0.153	0.8788
QDIFF18	63	0.333	0.223	1.496	0.1398
QDIFF19	63	-0.063	0.207	-0.306	0.7603
QDIFF20	63	0.587	0.199	2.946	0.0045
QDIFF21	63	0.317	0.110	2.874	0.0055
QDIFF22	63	0.413	0.129	3.193	0.0022
QDIFF23	63	0.571	0.176	3.241	0.0019
QDIFF24	63	-0.397	0.189	-2.103	0.0395
QDIFF25	63	-0.206	0.162	-1.275	0.2071
QDIFF26	63	0.048	0.255	0.186	0.8527
QDIFF27	63	-0.032	0.122	-0.261	0.7952
QDIFF28	63	0.397	0.162	2.443	0.0174
QDIFF29	63	-0.079	0.107	-0.743	0.4605
QDIFF30	63	-0.413	0.139	-2.973	0.0042
QDIFF31	63	-0.206	0.107	-1.937	0.0573
QDIFF32	63	-0.032	0.068	-0.468	0.6411

TABLE B-5. NAVIGATOR T-TEST RESULTS

POSIT=5

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	33	-0.515	0.302	-1.706	0.0976
QDIFF2	33	0.242	0.261	0.928	0.3603
QDIFF3	33	0.515	0.218	2.362	0.0244
QDIFF4	33	-0.394	0.265	-1.489	0.1462
QDIFF5	33	-0.758	0.292	-2.594	0.0142
QDIFF6	33	0.727	0.227	3.200	0.0031
QDIFF7	33	0.000	0.138	0.000	1.0000
QDIFF8	33	0.394	0.179	2.199	0.0352
QDIFF9	33	-0.576	0.246	-2.338	0.0258
QDIFF10	33	0.333	0.198	1.685	0.1017
QDIFF11	33	-0.636	0.245	-2.592	0.0143
QDIFF12	33	0.515	0.175	2.948	0.0059
QDIFF13	33	0.455	0.279	1.629	0.1130
QDIFF14	32	1.438	0.269	5.340	0.0001
QDIFF15	32	-0.031	0.349	-0.089	0.9293
QDIFF16	32	0.250	0.238	1.052	0.3008
QDIFF17	33	-0.364	0.199	-1.831	0.0764
QDIFF18	33	0.364	0.194	1.877	0.0697
QDIFF19	33	-0.545	0.185	-2.947	0.0059
QDIFF20	33	0.970	0.211	4.598	0.0001
QDIFF21	33	0.152	0.138	1.094	0.2820
QDIFF22	33	0.576	0.180	3.206	0.0030
QDIFF23	33	0.455	0.200	2.274	0.0298
QDIFF24	33	-0.273	0.239	-1.139	0.2632
QDIFF25	33	-0.091	0.262	-0.346	0.7313
QDIFF26	33	-0.424	0.282	-1.504	0.1425
QDIFF27	33	0.182	0.119	1.530	0.1358
QDIFF28	33	0.182	0.160	1.139	0.2632
QDIFF29	33	-0.333	0.193	-1.727	0.0938
QDIFF30	33	-0.182	0.119	-1.530	0.1358
QDIFF31	33	-0.576	0.238	-2.414	0.0217
QDIFF32	33	0.091	0.110	0.828	0.4138

TABLE B-6. TACTICAL COORDINATOR T-TEST RESULTS

POSIT=6

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	66	-1.076	0.166	-6.469	0.0001
QDIFF2	66	0.121	0.137	0.882	0.3810
QDIFF3	66	0.591	0.146	4.036	0.0001
QDIFF4	66	0.030	0.208	0.146	0.8847
QDIFF5	66	-0.788	0.261	-3.015	0.0037
QDIFF6	66	0.333	0.115	2.900	0.0051
QDIFF7	66	0.030	0.081	0.375	0.7085
QDIFF8	66	0.500	0.117	4.282	0.0001
QDIFF9	66	-0.697	0.153	-4.566	0.0001
QDIFF10	66	0.364	0.139	2.610	0.0112
QDIFF11	66	-0.773	0.206	-3.756	0.0004
QDIFF12	66	0.273	0.125	2.181	0.0328
QDIFF13	66	0.303	0.189	1.600	0.1145
QDIFF14	64	1.141	0.215	5.314	0.0001
QDIFF15	64	-0.391	0.215	-1.813	0.0746
QDIFF16	65	0.308	0.095	3.226	0.0020
QDIFF17	66	-0.273	0.147	-1.851	0.0687
QDIFF18	66	-0.106	0.132	-0.806	0.4231
QDIFF19	66	0.061	0.158	0.382	0.7034
QDIFF20	66	0.939	0.210	4.467	0.0001
QDIFF21	66	-0.030	0.103	-0.293	0.7706
QDIFF22	66	0.258	0.139	1.856	0.0680
QDIFF23	66	0.303	0.205	1.480	0.1438
QDIFF24	66	-0.773	0.208	-3.715	0.0004
QDIFF25	65	-0.446	0.177	-2.523	0.0141
QDIFF26	65	-0.169	0.210	-0.807	0.4229
QDIFF27	66	0.030	0.099	0.306	0.7602
QDIFF28	66	0.303	0.114	2.654	0.0100
QDIFF29	66	-0.439	0.143	-3.063	0.0032
QDIFF30	65	-0.446	0.150	-2.967	0.0042
QDIFF31	66	-0.576	0.160	-3.594	0.0006
QDIFF32	66	-0.061	0.091	-0.664	0.5091

TABLE B-7. SENSOR ONE T-TEST RESULTS

---------------------------------- POSIT=7 ----------------------------------

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	60	-0.467	0.200	-2.339	0.0228
QDIFF2	60	0.267	0.176	1.515	0.1352
QDIFF3	60	0.400	0.153	2.622	0.0111
QDIFF4	59	-0.169	0.222	-0.764	0.4478
QDIFF5	60	-0.917	0.244	-3.758	0.0004
QDIFF6	60	0.233	0.139	1.675	0.0993
QDIFF7	60	0.050	0.069	0.725	0.4715
QDIFF8	60	0.417	0.129	3.239	0.0020
QDIFF9	60	-0.617	0.158	-3.907	0.0002
QDIFF10	60	0.200	0.106	1.891	0.0635
QDIFF11	60	-1.083	0.273	-3.963	0.0002
QDIFF12	60	0.150	0.164	0.913	0.3652
QDIFF13	60	-0.017	0.191	-0.087	0.9307
QDIFF14	58	0.931	0.229	4.062	0.0002
QDIFF15	58	0.328	0.288	1.136	0.2606
QDIFF16	58	0.569	0.183	3.116	0.0029
QDIFF17	60	-0.100	0.148	-0.676	0.5015
QDIFF18	60	0.200	0.163	1.230	0.2236
QDIFF19	60	-0.117	0.254	-0.460	0.6475
QDIFF20	60	0.417	0.221	1.887	0.0641
QDIFF21	60	0.167	0.109	1.524	0.1328
QDIFF22	60	0.300	0.151	1.988	0.0514
QDIFF23	60	0.167	0.149	1.120	0.2671
QDIFF24	60	-0.500	0.205	-2.437	0.0178
QDIFF25	60	0.017	0.188	0.089	0.9296
QDIFF26	60	-0.133	0.224	-0.596	0.5532
QDIFF27	60	0.183	0.188	0.976	0.3332
QDIFF28	59	0.186	0.158	1.183	0.2415
QDIFF29	60	-0.333	0.177	-1.880	0.0651
QDIFF30	60	-0.133	0.188	-0.710	0.4807
QDIFF31	60	-0.233	0.178	-1.308	0.1961
QDIFF32	60	-0.017	0.061	-0.275	0.7841

TABLE B-8. SENSOR TWO T-TEST RESULTS

POSIT=8

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	25	-0.680	0.309	-2.198	0.0379
QDIFF2	25	0.440	0.265	1.660	0.1099
QDIFF3	25	0.200	0.216	0.926	0.3638
QDIFF4	25	0.400	0.306	1.309	0.2028
QDIFF5	25	-0.960	0.381	-2.522	0.0187
QDIFF6	25	0.480	0.209	2.295	0.0308
QDIFF7	25	0.080	0.080	1.000	0.3273
QDIFF8	25	0.440	0.327	1.346	0.1910
QDIFF9	24	-0.500	0.376	-1.330	0.1965
QDIFF10	25	0.520	0.239	2.177	0.0396
QDIFF11	25	-1.080	0.404	-2.674	0.0133
QDIFF12	25	-0.240	0.273	-0.881	0.3872
QDIFF13	25	-0.640	0.336	-1.904	0.0689
QDIFF14	23	1.043	0.277	3.761	0.0011
QDIFF15	23	0.174	0.411	0.424	0.6760
QDIFF16	23	0.391	0.306	1.277	0.2148
QDIFF17	25	-0.320	0.269	-1.189	0.2460
QDIFF18	25	0.240	0.348	0.690	0.4967
QDIFF19	25	-0.640	0.282	-2.268	0.0326
QDIFF20	25	0.720	0.286	2.518	0.0189
QDIFF21	25	0.080	0.114	0.700	0.4907
QDIFF22	25	0.600	0.337	1.782	0.0874
QDIFF23	25	0.160	0.229	0.700	0.4907
QDIFF24	25	-0.720	0.354	-2.036	0.0529
QDIFF25	25	-0.440	0.300	-1.464	0.1560
QDIFF26	25	-0.040	0.372	-0.108	0.9152
QDIFF27	25	-0.320	0.269	-1.189	0.2460
QDIFF28	24	0.000	0.190	0.000	1.0000
QDIFF29	25	-0.080	0.258	-0.310	0.7589
QDIFF30	25	0.280	0.363	0.771	0.4480
QDIFF31	25	-0.400	0.163	-2.449	0.0220
QDIFF32	25	-0.120	0.133	-0.901	0.3765

TABLE B-9. SENSOR THREE T-TEST RESULTS

POSIT=9

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	56	-0.661	0.179	-3.694	0.0005
QDIFF2	56	0.143	0.143	1.000	0.3217
QDIFF3	56	0.107	0.136	0.785	0.4357
QDIFF4	56	-0.125	0.191	-0.655	0.5151
QDIFF5	56	-0.518	0.291	-1.782	0.0802
QDIFF6	56	0.125	0.111	1.124	0.2661
QDIFF7	56	0.125	0.085	1.475	0.1460
QDIFF8	56	0.518	0.119	4.334	0.0001
QDIFF9	56	-0.482	0.180	-2.676	0.0098
QDIFF10	56	0.196	0.112	1.749	0.0858
QDIFF11	56	-1.339	0.255	-5.248	0.0001
QDIFF12	56	0.232	0.146	1.586	0.1185
QDIFF13	56	0.232	0.213	1.089	0.2809
QDIFF14	54	1.241	0.215	5.780	0.0001
QDIFF15	54	0.111	0.260	0.428	0.6707
QDIFF16	54	0.389	0.148	2.625	0.0113
QDIFF17	56	-0.357	0.191	-1.866	0.0674
QDIFF18	56	-0.107	0.168	-0.636	0.5273
QDIFF19	56	-0.018	0.201	-0.089	0.9297
QDIFF20	56	0.518	0.213	2.429	0.0184
QDIFF21	56	0.179	0.092	1.936	0.0581
QDIFF22	56	0.554	0.169	3.278	0.0018
QDIFF23	55	0.309	0.158	1.962	0.0550
QDIFF24	56	-0.661	0.214	-3.093	0.0031
QDIFF25	56	-0.054	0.177	-0.302	0.7637
QDIFF26	55	-0.309	0.223	-1.386	0.1715
QDIFF27	56	-0.036	0.238	-0.150	0.8811
QDIFF28	56	0.232	0.210	1.105	0.2740
QDIFF29	56	-0.411	0.144	-2.859	0.0060
QDIFF30	56	-0.268	0.209	-1.280	0.2061
QDIFF31	56	-0.161	0.157	-1.026	0.3093
QDIFF32	56	0.036	0.102	0.351	0.7271

TABLE B-10. INFLIGHT TECHNICIAN T-TEST RESULTS

-- POSIT=10 --

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	40	-0.375	0.205	-1.832	0.0746
QDIFF2	40	0.675	0.225	3.004	0.0046
QDIFF3	40	0.500	0.152	3.291	0.0021
QDIFF4	40	-0.450	0.253	-1.778	0.0832
QDIFF5	40	-1.000	0.275	-3.636	0.0008
QDIFF6	40	0.275	0.160	1.718	0.0937
QDIFF7	40	0.125	0.082	1.533	0.1334
QDIFF8	40	0.725	0.183	3.972	0.0003
QDIFF9	40	-0.425	0.143	-2.978	0.0050
QDIFF10	40	0.000	0.062	0.000	1.0000
QDIFF11	40	-1.400	0.253	-5.541	0.0001
QDIFF12	40	0.450	0.152	2.966	0.0051
QDIFF13	40	-0.050	0.193	-0.260	0.7966
QDIFF14	37	1.027	0.304	3.380	0.0018
QDIFF15	37	0.270	0.341	0.792	0.4338
QDIFF16	37	0.432	0.207	2.089	0.0438
QDIFF17	40	-0.175	0.202	-0.866	0.3920
QDIFF18	40	-0.025	0.216	-0.116	0.9086
QDIFF19	40	-0.325	0.249	-1.305	0.1996
QDIFF20	40	0.400	0.267	1.496	0.1428
QDIFF21	40	0.375	0.181	2.066	0.0455
QDIFF22	40	0.525	0.193	2.723	0.0096
QDIFF23	39	0.231	0.193	1.199	0.2381
QDIFF24	40	-0.175	0.211	-0.827	0.4130
QDIFF25	40	-0.025	0.201	-0.124	0.9016
QDIFF26	38	-0.105	0.304	-0.347	0.7308
QDIFF27	40	-0.225	0.222	-1.013	0.3173
QDIFF28	40	0.125	0.125	1.000	0.3235
QDIFF29	40	-0.750	0.174	-4.298	0.0001
QDIFF30	40	-0.575	0.196	-2.937	0.0055
QDIFF31	40	-0.375	0.228	-1.642	0.1087
QDIFF32	40	0.150	0.057	2.623	0.0124

TABLE B-11. ORDNANCE T-TEST RESULTS

POSIT=11

Variable	N	Mean	Std Error	T	Prob>|T|
QDIFF1	37	-0.946	0.245	-3.862	0.0004
QDIFF2	37	0.622	0.224	2.778	0.0086
QDIFF3	37	0.568	0.244	2.329	0.0256
QDIFF4	36	-0.056	0.316	-0.176	0.8615
QDIFF5	37	-1.216	0.320	-3.802	0.0005
QDIFF6	37	0.081	0.206	0.393	0.6968
QDIFF7	36	-0.083	0.083	-1.000	0.3242
QDIFF8	37	0.784	0.266	2.946	0.0056
QDIFF9	37	0.000	0.164	0.000	1.0000
QDIFF10	37	-0.027	0.137	-0.197	0.8446
QDIFF11	37	-1.243	0.441	-2.820	0.0078
QDIFF12	37	-0.027	0.147	-0.183	0.8556
QDIFF13	37	-0.216	0.174	-1.244	0.2217
QDIFF14	36	1.306	0.245	5.329	0.0001
QDIFF15	36	-0.472	0.327	-1.443	0.1580
QDIFF16	36	0.722	0.176	4.093	0.0002
QDIFF17	37	-0.216	0.260	-0.831	0.4117
QDIFF18	37	0.108	0.238	0.454	0.6526
QDIFF19	37	-0.324	0.280	-1.160	0.2537
QDIFF20	37	0.919	0.220	4.168	0.0002
QDIFF21	37	0.243	0.131	1.859	0.0713
QDIFF22	37	0.486	0.143	3.402	0.0017
QDIFF23	37	0.081	0.136	0.595	0.5557
QDIFF24	37	-0.432	0.291	-1.484	0.1465
QDIFF25	37	-0.297	0.208	-1.428	0.1619
QDIFF26	37	-0.162	0.289	-0.562	0.5778
QDIFF27	37	-0.378	0.230	-1.642	0.1092
QDIFF28	37	0.730	0.231	3.154	0.0032
QDIFF29	37	-0.378	0.252	-1.500	0.1422
QDIFF30	37	-0.324	0.271	-1.195	0.2399
QDIFF31	37	-0.432	0.321	-1.348	0.1861
QDIFF32	37	-0.054	0.116	-0.466	0.6437

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